DiskoBasis monitering

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ARCTIC STATION

Annual Report 2015

ARCTIC
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Front cover: R/V Porsild. Photo Andreas Vieli


SUZUKI

Chairman's Welcome

Professor Bo Elberling

Disko Bay constitutes an internationally unique study site and includes a large diversity of many of the different ways of living being characteristic for West Greenland. At the same time, Disko Bay has a large landscape and habitat diversity and a large geographical variation in climate both from North to South (from High Arctic to Low Arctic climate) and from West to East (from a very maritime to a more continental climate). This sets the scheme for many on-going research projects, which you can read about here - but hopefully also for future larger joint efforts with a multi-disciplinary approach.

For the same reasons, we are pleased that an expanded monitoring program was running in 2015. This is important for both maintaining a long term monitoring initiated in 1991 as well as supporting shorter projects with basic data. The program includes a new climate station, snow and sea ice monitoring, vegetation and lake monitoring as well as marine profiling. The monitoring data base includes climate data since 1991. Data show marked changes: winter temperatures are increasing and the extent of sea ice and snow on land is significantly reduced. In this annual report you can read more about the data being collected as part of the DiskoBasis monitoring program, funded by the Danish Ministry of Energy, Utilities and Climate.

The station is staffed year round with a scientific leader, a technical leader and a captain of R/V Porsild. I would like to acknowledge the excellent and hard work from our colleagues in Qeqertarsuaq. The staff is making it possible to conduct studies, also in the dark winter months at Arctic Station. By the end of the field season 2015 our scientific leader, Christian Juncher Jørgensen, decided to return to Denmark for another position. After Christian, Casper Tai Christiansen took over the position.

Scientific groups working at or near Arctic Station in 2015 have presented their work in this report. Thank you for the collaboration and all the efforts. Finally, I thank the board for a fruitful collaboration in 2015 and Gitte Henriksen for being such a qualified and enthusiastic administrator supporting me and the rest of the board.

Enjoy reading

Bo Elberling

Working with Greenland shark
Photo John Fleng Steffensen

Figure 1a. Position of the camera at Lyngmarksfjeldet (69°16'17''N, 53°32'48''W, Elevation 385 m a.s.l.). Photo Christian Juncher Jørgensen.

Figure 1b. Photos captured by the automatic camera on Lyngmarksfjeld at the following dates 19-04-2015, 19-05-2015 and 28-06-2015.

Figure 2. Map of the southern part of Disko island with DiskoBasis monitoring sites. 1) Lake Moræne sø/Sanningasup Tasia, 2) Røde elv multisonde, 3) Østerlien automatic weather station AWS2, 4) Camera-site Lyngmarksfjeld, 5) Lake Kangaarsuup Tasia, 6) Pjeturssons moræne. Red circle mark Arctic Station and red square mark CENPERM experimental site in Blæsedalen. The satellite/aerial background image is copied from Google Earth Image©2016 Digital Globe. This section is based on two images. The main part of the map is covered by an image provided by IBCAO, imagery date: 7/31/2015 and the very left part is covered by an image provided by Terrametrics, imagery date 7/22/2013.

DiskoBasis Monitoring

Charlotte Sigsgaard, Christian Juncher Jørgensen, Casper Tai Christiansen, Per Juel Hansen, Kirsten Seestern Christoffersen, Alistair McConnell, Kjeld Akaaraq Mølgaard, Aart Kroon, Thomas Friborg, Birger Ulf Hansen & Bo Elberling

DiskoBasis is the ecosystem monitoring program at Arctic Station. The program has increased the monitoring at Arctic Station by introducing several new activities to the ongoing monitoring initiated in 1991. New implementations and new parameters have been included, especially within the fields of terrestrial and hydrological monitoring. The enhanced focus on the long term monitoring in the area has been partly financed by the Danish Ministry of Energy, Utilities and Climate since 2013 and by the University of Copenhagen, who owns Arctic Station. Currently, the program is associated with the Greenland Ecosystem Monitoring program (GEM) and has the ambition of being fully incorporated in the GEM collaboration. All DiskoBasis data are public domain and validated data are available from the Department of Geosciences and Natural Resource Management, University of Copenhagen. Contact: C. Sigsgaard (cs@ign.ku.dk). For additional information about DiskoBasis, please refer to the homepage www.arktiskstation.ku.dk/Research/Monitoring. A summary of selected parameters collected by DiskoBasis in 2015 are presented in this section.

Implementations 2015

Sea ice monitoring was improved when a new automatic camera was installed and became operational at the Lyngmarksfjeld in April (Figure 1 and 2). So far, estimates of sea ice coverage have been based on daily visual observations from Arctic Station since 1991. The field of view has markedly increased with the new camera, mounted 385 m a.s.l. It improves the opportunity to follow the formation and break-up of the sea-ice and a chance to track the drifting ice mountains in the area. Besides, the sediment plume from the river Røde Elv can be observed in the surface water outside the river delta where freshwater enters the sea (Figure 1b). At the moment, three daily photos are being captured.

Weather and Climate

The mean annual air temperature (MAAT) measured at Arctic Station was -4.5°C in 2015, which is the lowest recorded since 1994 (Figure 3). The low annual mean temperature was mainly due to winter temperatures being below the average (Figure 3 and 4). July had a mean monthly temperature of 9.2°C and was the only month being warmer than the average for the period 1992-2015. Frequently, positive temperatures occurred from early May. Snow disappeared in the area around the automatic weather station in Østerlien by early June and the soil started to thaw (Figure 5). A new continuous snow layer covered the area from 2 October 2015. The snow depth at the weather station increased to 85 cm after a major snow event on 20 November. This is among the maximum snow depths registered since 1991. Soil freezing was very slow due to the insulating effect of the deep snow. Only the upper 30 cm of the soil had temperatures below zero by the end of December 2015.

Precipitation has been measured just outside Arctic Station as part of the meteorological monitoring since 1991. It is mainly liquid precipitation or rain that is registered because the collector is a

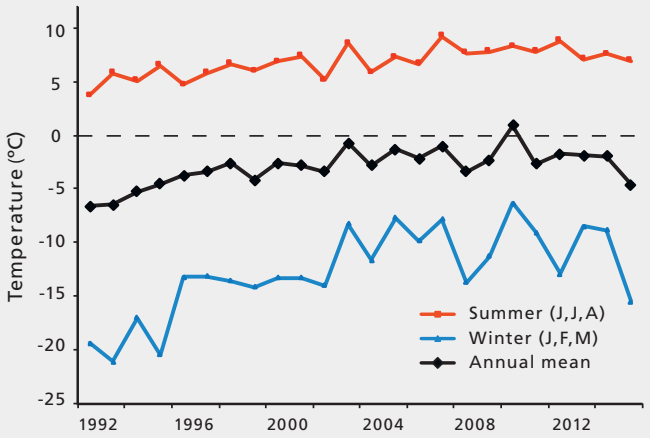


Figure 3. Annual mean air temperatures at Arctic Station from 1992 to 2015 and mean air temperatures for the warmest months (June, July and August) and the coldest months (January, February and March).

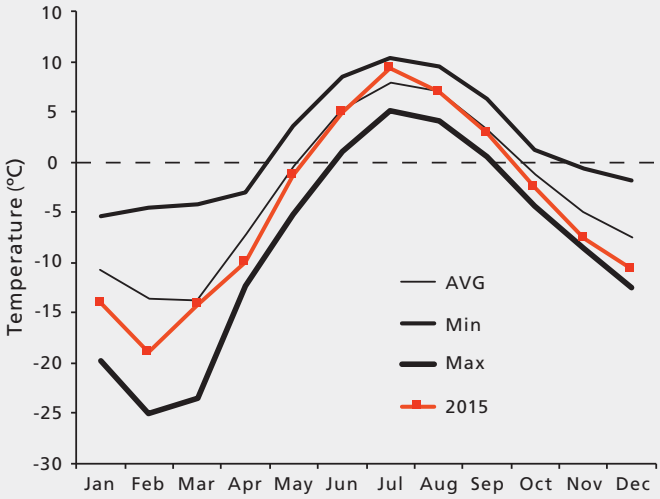


Figure 4. Mean monthly air temperatures from the automatic weather station in 2015 compared to minimum, maximum and average for the period 1992-2015.

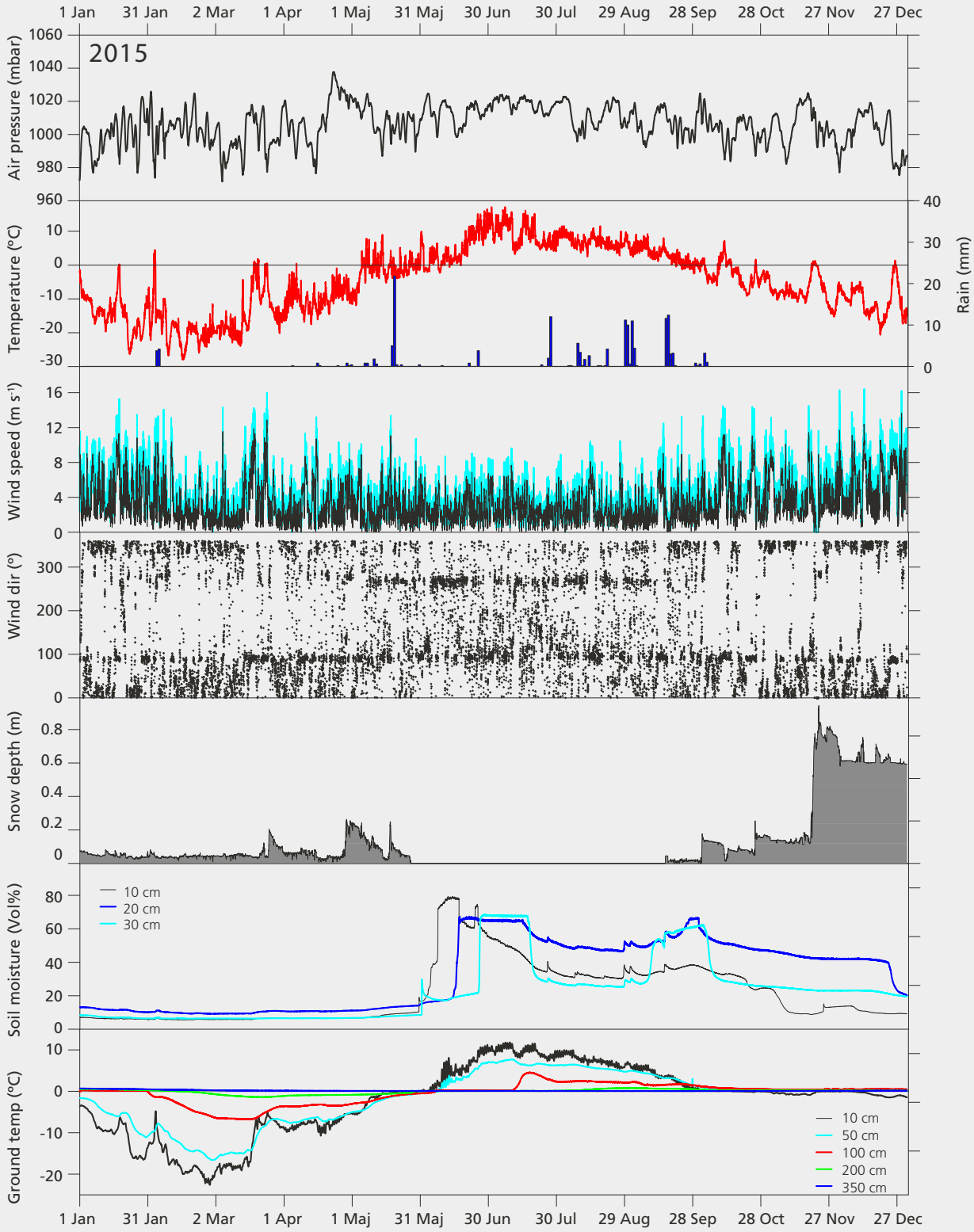


Figure 5. Temporal variations over 2015 (data logged every 30 min) of selected parameters from the automatic weather station (AWS-2) in Østerlien. Air Pressure, air temperature, precipitation (rain measured at AWS-1), wind speed (mean and max), wind direction, snow depth, soil moisture and ground temperatures from 10, 50, 100, 200 and 350 cm below surface.

non-heated model. Some snow may however enter the collector and will be registered if temperatures are high enough to melt the snow before the wind sweeps it out of the bucket. A total of 165 mm liquid precipitation was measured in 2015 (Figure 5). The majority of the rain was registered in August and September like in most other years.

The total summer precipitation was in the low end compared to previous years (Figure 6).

Ground temperatures down to 300 cm have been registered in a profile outside Arctic Station since 1991. Permafrost conditions were for the last time present at the depth of 175 cm in the early 1990s. The ground temperature data showed an overall

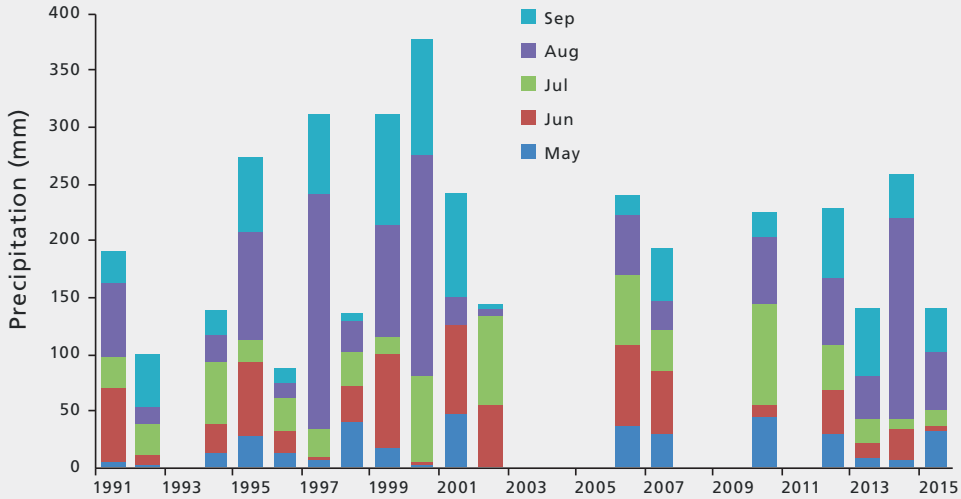


Figure 6. Precipitation/rain measured just outside Arctic Station. Stacked monthly amounts from May to September are shown from 1991 to 2015.

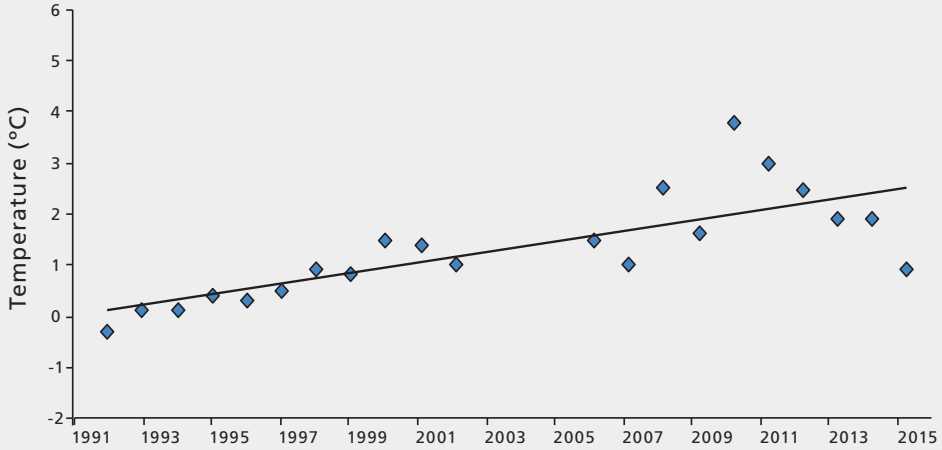


Figure 7. Annual maximum ground temperature registered 175 cm below the soil surface.

increasing trend in the annual maximum soil temperature until 2010 and a steady decrease afterwards (Figure 7). Ground temperatures at 175 cm´s depth remained above zero from 26 July to 7 October in 2015 and reached a maximum temperature of 0.9°C (15 September). New soil temperature sensors were installed in Østerlien in 2012 and 2013 and data from these sensors revealed frost penetration or seasonal freezing down to 200 cm and no permafrost within the upper 350 cm of the soil. The present set-up gives no information below 350 cm.

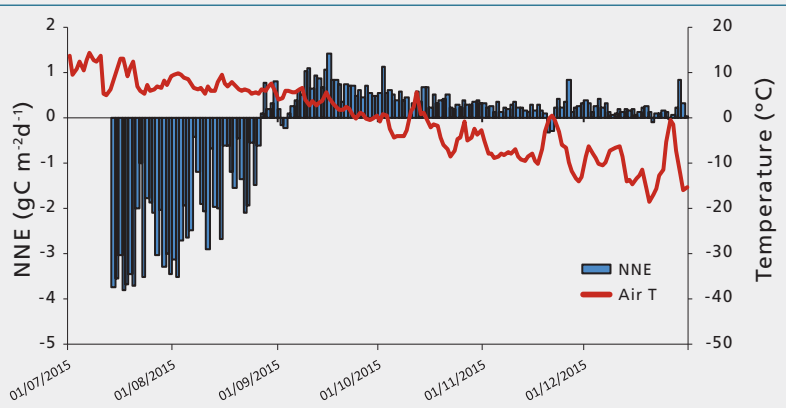
Carbon dioxide gas exchange

Measurements of carbon dioxide (CO_2) exchange rates between land and atmosphere have been recorded in Østerlien since November 2012. Østerlien is a relatively moist area covered by low vegetation of dwarf shrubs. Data are continuously collected using the eddy covariance system consisting of an ultrasonic anemometer and infrared gas analyzer (Figure 8). The location next to Arctic Station makes year-round measurements possible, because the instruments can be powered by cables from the station and permanent staff is available to service the station throughout the winter. The system was not in operation until mid-July due to a break down and repair of instruments. When the measurements were taken up, it was just about the time where the daily carbon uptake was peaking due to high photosynthesis rates (Figure 8).

The net carbon uptake ceased with the growing season and by the end of August the system in Østerlien switched from being a net sink to being a net source of carbon. The maximum emission of 1.5 gC m^{-2} was measured on 21 September. Small net emissions were registered even when diurnal mean air temperatures dropped below zero and snow covered the ground.

River water discharge and suspended sediment

Monitoring of the discharge and water chemistry in the river Røde Elv (Kuussuaq) has been made since 2013. Runoff from Røde Elv drainage basin is an important part of the water balance and an essential tool to estimate the total fluxes of freshwater, sediment and nutrients from land to ocean. The drainage basin of Røde Elv varies in elevation from 0 to about 800 m a.s.l. and the size is estimated to 101 km^2 of which roughly 20% is glacier covered.



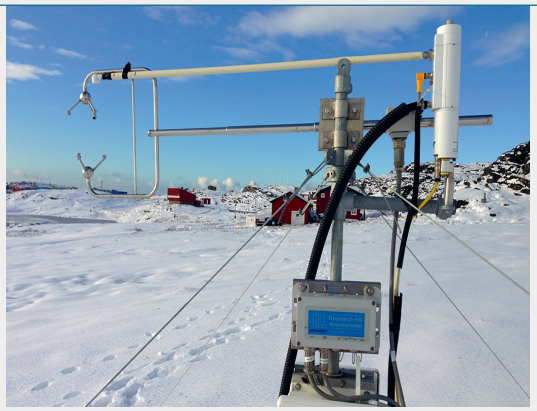


Figure 8. Temporal variation of diurnal net ecosystem exchange (NEE) and air temperature measured at Østerlien in 2015. NEE refers to the sum of all CO_2 exchange processes, including photosynthetic CO_2 uptake by plants, plant respiration and microbial decomposition. Fluxes directed from the land surface to the atmosphere are positive (i.e. a net release of CO_2 from the land surface to the atmosphere), while fluxes directed from the atmosphere to the land surface are negative (i.e. net uptake of CO_2 by the land, from the atmosphere).

In 2015, the multisonde was mounted on a steep bedrock north of the bridge at the eastern side of the river (Figure 9 and 2). Multiple parameters, like water level, water temperature, turbidity, conductivity and pH were automatically recorded every 10 minutes (Figure 10). Besides, water samples were manually collected twice a week and later analyzed for suspended sediment and chemical composition. Discharge measurements were carried out in order to transform the automatically logged water level into discharge.

A total of about 50 mio m^3 freshwater was transported from land to the sea in the period from 18 June to 30 September. During the same period about 6,000 ton of suspended sediment were transported into the sea. These total numbers must be regarded as estimates and need to be refined when more discharge measurements are carried out at high water levels and a more robust discharge-water level relation is available.

The highest suspended sediment concentration of 1000 mg l^{-1} was registered right after a rain event in late-August. A few days later, the suspended sediment was more or less depleted and the diurnal variation in the water level and water discharge records declined. The diurnal variation in water level and discharge are mainly controlled by the melting of snow and ice from the glaciers and therefore it decreases when air temperatures drop and ice melting stops.

Lots of snow in the early winter. Photo from 30 November 2015. Kjeld Akaaraq Mølgaard

Lake monitoring

Two lakes, Sanningasup Tasia (Morænesø) in Blæsedalen and Kangaarsuup Tasia at Kangaarsuk, were sampled for limnological parameters in 2015 (for location see Figure 2). Sanningasup Tasia has a max depth of 5 m and an estimated average depth of 1.5 m. The catchment area is small (0,81km^2) with the majority of the water coming from the nearby moraine hills via a small inlet in the eastern end. An outlet in the western end drains into Røde elv. The lake is typically ice and snow covered from November to June. The biota includes mosses, plankton and invertebrates. There is no fish.

Kangaarsuup Tasia has a max depth of 7 m and an estimated average depth of 2-3 m. The lake has a catchment area of 0.69 km^2 and is connected to a shallow lake further to the West. An outlet drains directly into the sea via a small stream. The last approximately 10 m runs underneath a beach ridge of stones. The ice-on and off dates are not known but is assumed to be similar to Sanningasup Tasia. The biota includes plankton, invertebrates as well as a fish population of landlocked arctic char (*Salvelinus alpinus*). The aquatic vegetation (mosses) is fairly sparse.

The monitoring protocols include manual samplings of basic water quality parameters during winter and summer combined with visual observations of ice and snow conditions. In 2015, no winter sampling was performed. The summer sampling events were performed during 9 to 14 July, which was 2 to 3 weeks after ice had melted. At this time, the lakes had fairly warm waters (15-16°C), pH around 7.5, 100% oxygen saturation, the chlorophyll concentrations probably peaked (3.2 to 3.5 µg l^{-1}), and the total phosphorus and total nitrogen were at levels expected for arctic lakes (Table 1). The zooplankton-

Figure 9. The location of the multisonde in Røde Elv (69° 15' 13''N, 53° 29' 53''W, 10 m a.s.l. and ca 460 m from the coast). Photo from 21 September 2015 Charlotte Sigsgaard.

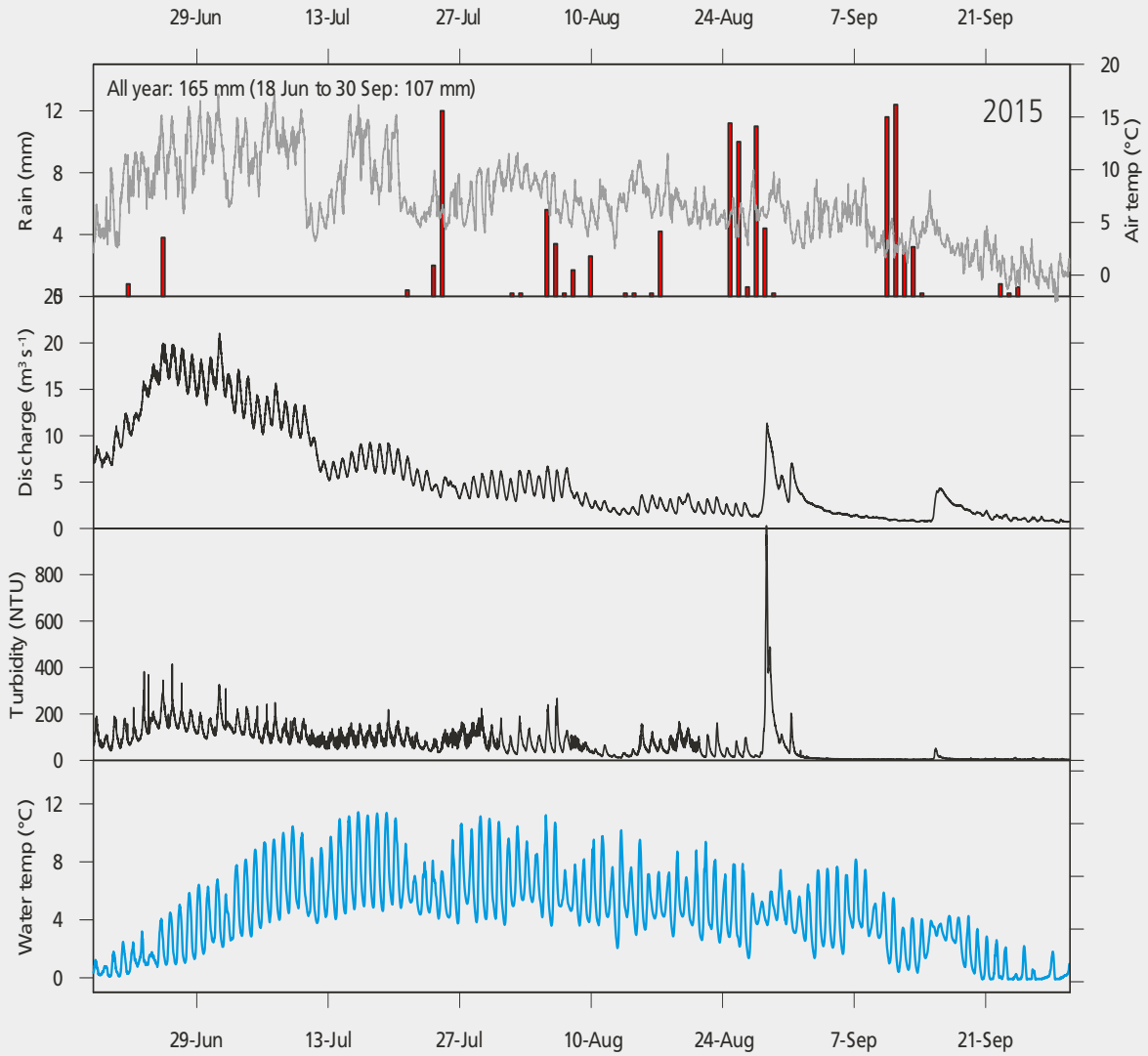


Figure 10. a) Rain and air temperature from the automatic weather station at Arctic Station b) water discharge (calculated from water level variations and manual discharge measurements) c) turbidity (~close related to suspended sediment concentration in mg l^{-1}) and d) water temp.

Table 1. Basic water quality parameters sampled during 9-14 July 2015.

Parameter	Sanningasup Tasia (Moræneso)	Kangaarsuup Tasia
Temperature (°C)	16	15
pH	7.4	7.6
Oxygen (%)	100	100
Chlorophyll pelagic (µg L^{-1})	3.5	3.2
Chlorophyll sediment (mg m^{-2})	58	Not sampled
Total phosphorus pelagic (µg L^{-1})	15	25
Total nitrogen pelagic (µg L^{-1})	333	272
Zooplankton communities (dominating by numbers)	Cyclopoid nauplii, *Daphnia longispina* and *Macrothrix hirsuiticornis*	Cyclopoid nauplii and copepedites, *Daphnia longispina*

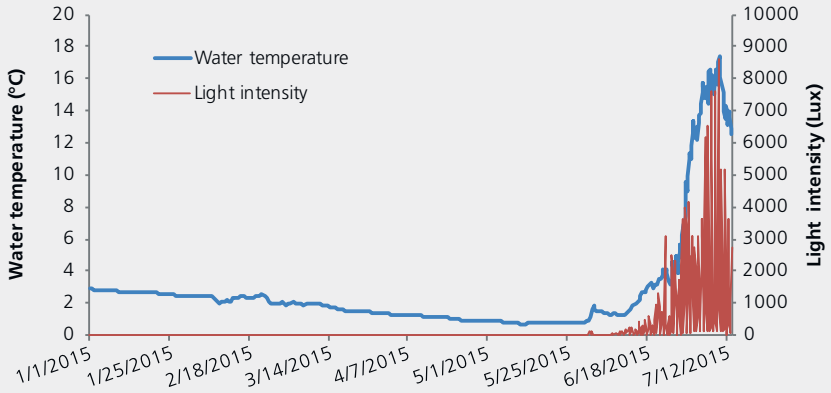


Figure 11. Water temperature and light intensity measured continuously at 2 m above the bottom in Sanningasup Tasia (Moræneso) from January to 13 July 2015.

comunities were assessed in both lake and reflected a strong dominance by cyclopoid copepods followed by small-sized cladocerans *(D. longispina and Macrothrix hirsuiticornis)*. The density of cladocerans was low in Kangaarsuup Tasia due to the presence of fish.

A rig mounted with data loggers is placed at the bottom of the deepest part of the lake Sanningasup Tasia. The loggers continuously record light and temperature 2 m above the lake bottom. Temperature data from the loggers showed that Sanningasup Tasia was ice covered until late June and that the highest water temperature (16°C) was reached on 7 July (Figure 11).

Marine monitoring

Marine monitoring has been performed at Arctic Station since 1924. In the present marine monitoring program, depth specific measurements of ocean water temperature, salinity, conductivity, density, oxygen content and fluorescence are performed with a CTD-probe from the R/V Porsild or from the sea ice when possible. The measurements are carried out on a monthly basis at three fixed positions. The deepest profile "Fast Station" extends to 300 meters depth and is located approximately 6 km south of Qeqertarsuaq (69°11´ N, 53°31´ W). Water temperature and salinity data from this position has been sampled more or less extensively as part of the routine sampling from Arctic Station and associated research projects since 1973 (Figure 12) and on a more irregular basis in the same area since 1924.

Average water temperatures measured in July are shown for 3 different depths (10, 50 and 200 meter) in Figure 12 illustrating surface water, intermediate water and deep/bottom water. Besides the annual variations there seems to be an increasing trend in the water temperature within the period from 1992 to 2015. This corresponds well with the increasing air temperature in the summer months within the same period (Figure 3). However, the system is much more complex and air temperature is only one parameter/factor that influences water temperature. The system is also highly controlled by presence of ice cover, vertical mixing of the water body, changes in freshwater discharge, and larger scale current patterns.

Collecting water samples in Morænesø. Photo Kirsten S. Christoffersen

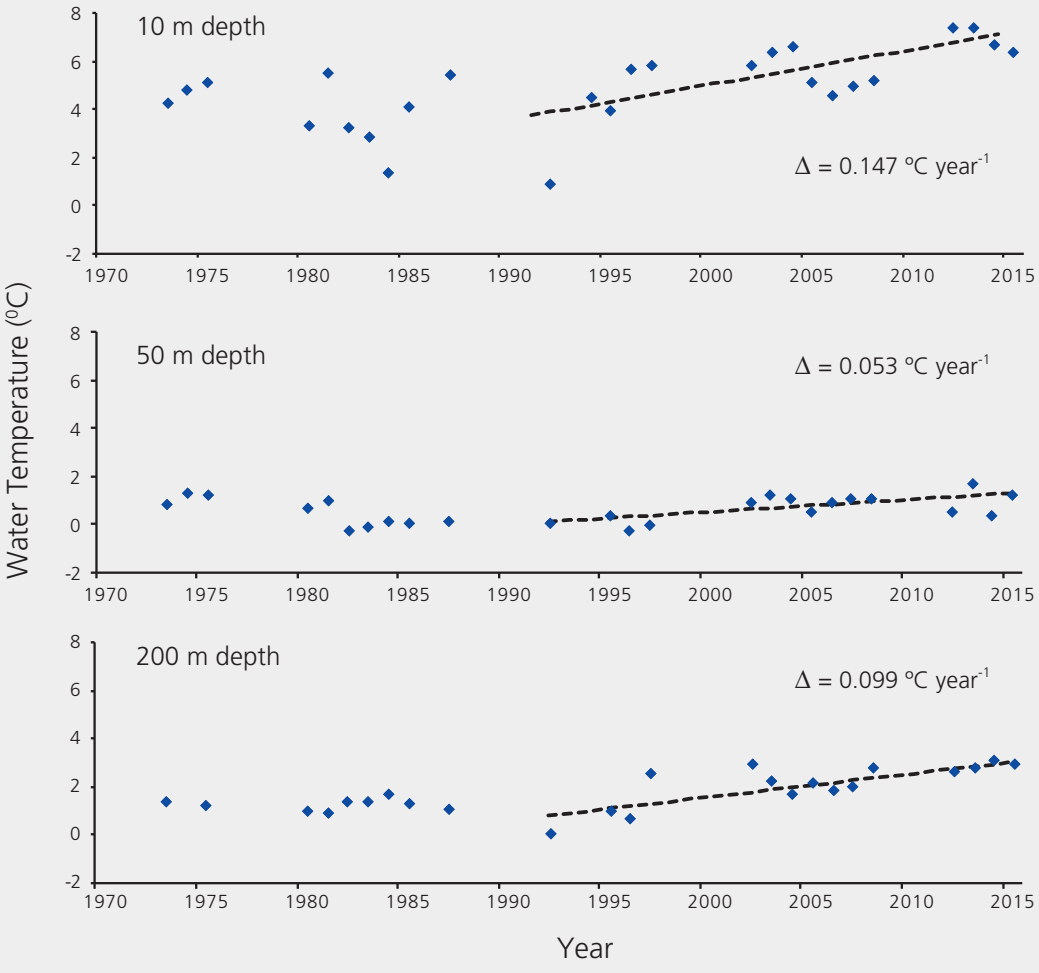


Figure 12. Average water temperature in July measured in a vertical profile at "Fast Station". Data are shown for 10, 50 and 200 m depths. Trend lines are shown for the period 1992-2015 which is the same period where weather data have been measured at Arctic Station. Triangles refer to the annual increase in temperature –the slope of the trend line.

Research Projects

Greenland Margins: Glacial ice, ocean and atmospheric dynamics (MARGINS)

Kerim Hestnes Nisancioglu, Jostein Bakke, Henning Åkesson, Department of Earth Science, University of Bergen and the Bjerknes Centre for Climate Research, Bergen, Norway, Øyvind Paasche, Bergen Marine Research Cluster and University of Bergen, Bergen, Norway, Inger Marit Kolstadbråten

The main aim of the MARGINS project carried out by the University of Bergen, Norway is to reconstruct the retreat of the Greenland ice margin from its glacial maximum extent out on the shelf to its present position in the fjords. In particular, we are interested in the retreat rate of the Ilulissat glacier and its response to climate changes through the last deglaciation (20 thousand years ago and up to the present). The glacial retreat is also being simulated using a dynamical ice flow model giving a full de-glacial history of one of the major glacial systems on Greenland.

Tectonic study of the Nuussuaq Peninsula: a 3D perspective of an oblique volcanic passive margin

François Chauvet, Huixin Guan, Laurent Geoffroy, IUEM, University of Brest, France

The Disko-Svartenhuk area in West Greenland allows the investigation of the structure and development of the inner-part of a Volcanic Passive Margin (VPM). In 2015, we focused on the 3D structure of the Nuussuaq Peninsula, a particularly oblique segment regarding the trend of regional tectonic stretching during the Paleogene. We aim at reconstitute the architecture of an oblique VPM by combining the field measurements, 3D analysis of high-resolution satellite imagery and Ion-GXT-seismic data worldwide.

ArcAlpNet 2.0: Assessing and managing resilience to climate change in Qeqertarsuaq, Greenland

Tobias Luthe, Melanie Rottmann, Department of Living Environment, University of Applied Sciences, HTW Chur, Switzerland

ArcAlpNet (Social Network Governance Measures of Climate Resilience in the Alps and the Arctic) identifies collaborative social network patterns together with socio-cultural, relational and behavioral factors that increase or inhibit resilience to environmental change in the community of Qeqertarsuaq on Disko Island in Greenland. The community shows a clustered structure with an overall low density of linkages and low formal collaboration. Some more central actors take over a leverage function with most influence in the community. The clustered network structure indicates a high potential for innovation, which is supported by the qualitative interviews. Network positions and functions are quite diverse and in transition. As part of the qualitative interviews, the existence of a bottom-up created innovation network in the community of Qeqertarsuaq was detected. Resilience management ideally needs to include and start from these actors who function as leverage hubs. Local follow-up transition workshops are planned.

Assessing spatial and temporal variations in oceanic conditions of Ata-Sound Fjord

Nicholas Beaird, Woods Hole Oceanographic Institution (WHOI), USA, Andreas Vieli, Martin Lüthi, Remy Mercenier, Christoph Rohner, Andrea Walter, University of Zurich, Switzerland

The aim was to obtain an understanding long-term outlet glacier calving dynamics with a combined high-resolution field,- remote-sensing- and modeling approach. Despite difficult ice pack conditions, a hydrographic cruise along Ata Sound consisting of 40 CTD-stations and the deployment of two moorings was successfully undertaken in June 2015. Water properties similar to August 2014 were found, but layer thicknesses were substantially different and seasonal Warm Polar Water was absent in 2015. The results imply strong seasonality and/or interannual variability of water masses in Ata Sound and limited access of the deep warm Atlantic Waters to the calving glacier fronts.

Studies of fate and effects of chemical herders in High-Arctic environment

Kim Gustavson, Rasmus Nørregaard, Eva Friis Møller, Janne Fritt-Rasmussen, Department of Bioscience Aarhus University, Denmark

The purpose of the work was to study the toxicity and bioaccumulation of the herders with the

Studying macro invertebrates from homoeothermic streams. Photo Kirsten S. Christoffersen

High-Arctic copepod (Calanus hyperboreus), as well as to study the biodegradation of the herders in Arctic waters at low temperature. Based on the studies it was concluded that one of the herders due to high toxicity and bioaccumulation, and slow degradation is not feasible to be used for combating oil spill in arctic areas.

Grazer-Phytoplankton Interactions in the Arctic Ecosyste

Nina Lundholm, Sara Hardardottir, Ditte Marie Hjort-Jensen, Natural History Museum of Denmark, University of Copenhagen, Denmark, Uwe John, Sylke Wohlrab, Bernd Krock, Alfred-Wegener Institute, Germany

We explored the interaction between grazing copepods and different diatoms, as we know from previous years that grazing copepods elicit a response in diatoms resulting in increased toxin production. We explored the kinetics of the induction of the toxin production, as well as the relaxation in production after grazing stopped, and simultaneously we followed the accumulation and release of the toxin in the copepods. In another study we compared the genetic background for the response in diatoms exposed to grazers; i.e. gene regulation patterns in the organisms, in order to understand the physiological background for the reactions.

Microbial nitrogen cycling associated with living copepods, their fecal pellets, and carcasses

Peter Stief, Ann Sofie Birch Lundgaard, Department of Biology, University of Southern Denmark, Denmark

We investigate the role of the copepod Calanus hyperboreus as a microbial hotspot for aerobic and anaerobic nitrogen cycling in the marine pelagic. Living copepods, their fecal pellets, and carcasses may provide suitable microhabitats for nitrogen cycling due to locally enhanced nitrogen availability and the presence of oxygen-depleted microniches. C. hyperboreus emits nitrous oxide and excretes ammonium, but apparently does not support N2 production by denitrification.

Effects of ocean acidification on Calanus glacialis populations

Peter Thor, Norwegian Polar Institute, Tromsø, Norway, Allison Bailey, Torkel Gissel Nielsen, Martin Candee, Technical University of Denmark, Denmark

Ocean acidification is changing the Arctic and many animal populations experience severe effects. Such effects may be alleviated by phenotypic diversity among populations. We found significant differences of pH reaction norms between Disko Bay and Svalbard populations of the copepod Calanus glacialis. This may contribute to so-called evolutionary rescues from ocean acidification in this species.

Metabolic rate and estimated life span of Juvenile Greenland Sharks (Symniosus microcephalus)

John Fleng Steffensen, Marine Biological Section, University of Copenhagen, Denmark, Peter G. Bushnell, Indiana University South Bend, USA and Kristian Vedel, Øresundsakvariet, Denmark

The primary aim of the project was to estimate the lifespan of Greenland sharks based on measured metabolic rates. To accomplish this, a 1600 liter resting respirometer was designed and built at the Arctic Station, submerged in the Qeqertarsuaq harbor and tied up to a dock. Oxygen concentration, saturation, temperature and salinity were continuously measured with an YSI 6820 Logging CTD. The Greenland sharks were caught with longlines approximately 2 nm east of Qeqertarsuaq harbor at depths between 200 and 250 meters. Each long line was equipped with 10 size 0/5 shark hooks, attached 5 meters apart, each with a 1 meter long steel chain leader. The longlines were set from R/V Porsild or the dinghy, and left fishing for between 12 and 24 hours. When a shark was caught it was fitted with straps around the peduncle and pectoral fins and towed alongside a dinghy at a speed slower than 0.5 knots from the fishing site to the respirometer in Qeqertarsuaq harbor. Once positioned close to the respirometer, a diver was instructed in getting the shark in the respirometer box. Metabolism of the shark was then measured over the following 24 hours. After the experiment the sharks were tagged with a Floyd ID-tag, and released. In total 3 sharks with total length up to 330 cm and total mass up to 346 kg were caught and had metabolic rates determined. Unfortunately, the sharks left the area making it impossible to catch and measure metabolism in additional animals during the time that remained for our study.

Bowhead whale singing behavior – diel patterns and mimicking ability

Laia Agustí Olivas, University of Copenhagen, Denmark, Outi Tervo, Greenland Institute of Natural Resources, Greenland

Bowhead whale singing behavior was monitored through February and March using a land based cable array revealing a new song for the 2015 season. The playback experiments were conducted as planned under very difficult conditions on sea ice (temperature below -25 °C). The acoustic data obtained from the project will be used for a MSc thesis of Laia Agustí Olivas.

Past and present influence of exchange of ocean water on subsurface melt at a large tidewater glacier - POEM, Disko Fjord and Sermilik Fjord, Greenland

Kristoffer Skinnebach, IGN, University of Copenhagen, Denmark

The main aim of the project is to reconstruct the changing calving and melt from glaciers into Sermilik Fjord and Disko Fjord over the last ~120 years. This is done by sediment coring and measurements of suspended sediment behavior. Temperature is being reconstructed by use of biological proxies (Diatoms, dinoflagellates and TEX86). Focus is also given to the impact of flocculation on transport of iron from land to sea.

Mapping of raised beach ridges at Lakse Bugt, Disko, using ground-penetrating radar

Priscila Emerich Souza, Science without Border/ University of Copenhagen, Denmark, Aart Kroon, CENPERM/IGN, Lars Nielsen, IGN, University of Copenhagen, Denmark

The project focusses on internal beach ridge structure mapped with ground-penetrating radar. Both modern and fossil systems are investigated. Based on the modern systems, we investigate how the internal structure relates to sea-level. The mapping of the fossil systems will be used to reconstruct relative sea-level variation through parts of the Holocene.

ALCHEMI

Catherine Larose, Christoph Keuschnig, University of Lyon, France

The major goal of the ALCHEMI research project is to determine the role of Arctic microorganisms in ecosystem functioning in the context of change. This goal was reached by identifying the temporal and spatial variations of biotic inputs and focused on aspects related to microbial colonization, environmental selection, community evolution and stability and biodiversity in the snow and transition zones, i.e. the air-snow interface and the snow-soil interface.

Methane uptake by dry non-vegetated soils in the Disko Bay area

Tue Mariager, IGN, University of Copenhagen, Denmark

Methane uptake by dry non-vegetated soils has been investigated for three different study sites in the Disko Bay area. The study has been based on chamber measurements using a high portable fast deployable chamber system consisting of non-collar chambers and an Ultra-Portable Greenhouse-Gas Analyzer (UGGA). Methane uptakes where detected in almost all investigated sites, with average values of -7 µmol m-2 s-1 for the basaltic soils around Arctic Station, -10.5 µmol m-2 s-1 for the sandstone soils at Skansen and -5 µmol m-2 s-1 for the gneissic soils close to Eqi, 80 km north of Ilulissat.

Aeolian inoculation of a glacial surface

Karen Cameron, Carsten Suhr Jacobsen, Oliver Müller, University of Copenhagen, Denmark

Several research studies have suggested that airborne biota is a likely key for the inoculation of glaciers and snow surfaces. This project aims to challenge this hypothesis by statistically comparing the DNA of microbial communities collected from air, snow, ice and melt water samples from the Lyngmarksbræ glacier area, during the melt season (late-May to mid-August). During 3 months of field work, we amassed and processed 231 samples around and at the Arctic Station. The sequences of 192 of these samples are now ready for analysis.

CENPERM experimental work in Blæsedalen and at Lyngmarksfjeldet

Field work in 2015 was focused on the ongoing measurements at the snow fence site in Blæsedalen established in 2012, upscaling in relation to geomorphology and marked changes in the landscape and a new established site along a transect near the retreating ice front at Lyngmarksfjeldet. Several subprojects have been completed and some preliminary results are described below.

Methane and nitrous oxide and emissions at plot level manipulated with summer and winter warming

Bo Elberling, Per Ambus, Anders Michelsen, Mathias Christian Riis

The objective of the project was to measure the emissions of nitrous oxide (N_2O) from dry and wet tundra systems as influenced by summer and winter warming. Nitrous oxide is a powerful greenhouse gas and is emitted due to biological N-cycle processes in the soil. Field work was carried out in August 2015 in the snow-fence experiment in Blæsedalen using the static gas-flux chamber technique deployed to tundra plots under ambient conditions (A), plots exposed to summer warming by open top chambers (W) and plots exposed to winter warming by increased snow cover during winter (S), and the combination WS. During the field campaign surface soil was collected in the experimental plots for assay of N_2O cycling enzyme activity. Generally N_2O emissions were small (<6 µg N m^{-2} h^{-1}). The preliminary data analysis suggests for the dry tundra that summer warming may increase N_2O; for the wet tundra summer warming has no effect whereas the increased snow cover seems to reduce N_2O emissions.

Methane exchange rates were measured at the same plots as nitrous oxide in order to complete the landscape-integrated methane budget. Methane exchange rates were also measured in relation to a watering experiment to explore the role of soil moisture on methane uptake rates at barren ground.

Sampling of snow on the glacier. Photo Tobias Luthe

Warming and snow effects on BVOC emissions from a wet fen

Riikka Rinnan, Magnus Kramshøj, Frida Lindwall, Anders Michelsen, Sophie Sylvest Svendsen

We assessed the effects of summer warming and increased winter snow depth on the emission of biogenic volatile organic compounds (BVOC) from a wet fen. The emission of isoprene, which was the dominant BVOC, increased by 340% under the moderate warming using open top chambers (OTCs). While the emission of BVOCs from vegetation has been intensely studied, potential emissions from soil are largely uninvestigated. In order to assess the importance of arctic poorly vegetated areas as a BVOC source, we studied emissions from a dry barren soil area. In this area, an experiment had been setup to assess effects of climate change. Five plots were warmed by OTCs, five received doubled average precipitation, five received both warming and precipitation treatments and five were un-manipulated controls. The preliminary analyses suggest that the BVOC emissions from this area are low compared to vegetated areas and that the emissions are slightly increased by additional precipitation.

Permafrost distribution, water flow and nitrogen addition along a hill slope

Bo Elberling, Karsten Høgh Jensen, Anders Michelsen, Sebastian F. Zastruzny

A new field site was established collecting data relevant for the temperature propagation and the water and solute transport in the active layer on a slope stretching 80 m in Blæsedalen. The distribution of the permafrost and thickness of the active layer was estimated with electric resistivity tomography and auger probing. Soil profiles of the active layer under different vegetation and positions along the slope was assessed, bulk thermal properties of the soil measured and soil samples were collected for further analysis of carbon content, porosity and water content. Additionally, 14 soil sensors were installed, measuring water content, temperature and electric conductivity. A tracer (NaCl) was applied at two locations and plume migration was monitored over 20

days by sensors and auger probing. Active layer thickness along the slope varied between 20 and 60 cm, close to the top no solid ground ice was found until a depth of 120 cm. Active layer depth was deeper close to the foot of the slope and showed large correlation to the vegetation. The travel path of the plume follows the slope but shows tendencies of following the permafrost topography during lower saturations. Spatial distribution of the saturation depends on the surface- and permafrost table topography. Movement of solute is controlled by the saturation and is therefore non uniform along the slope and shows strong correlation to weather events under low saturation. A labelled nitrogen-experiment was initiated in 2014 and a first sampling of plant leaves was made downstream from sites where nitrogen addition was made at the permafrost table. Nitrogen has moved downhill and is potentially available to plants further down on the hill slope.

Soil-plant interaction in a glacial foreland

Per Ambus, Bo Elberling, Marie Flyger, Anders Michelsen, Ole Humlum, Mathias Christian Riis

A new site was established at the base of the Lyngmark glacier on Disko Island which recently has been exposed due to the retreating glacier. Plots were established along a transect from the glacier and with increasing distance and time since exposure from the retreating glacier. Observations reveal a glacial recession rate of about 130 m for the last decade based on satellite image analysis. Sampling along 6 parallel transect lines reveal an ongoing acidification, soil carbon and nitrogen accumulation following the glacial retreat. Carbon and nitrogen levels correlated with the observed increasing vegetative cover and species diversity. Further investigations focus on the nitrogen sources and turnover in the foreland and the links between soil development and the succession of microbial groups and higher plant.

Mapping geomorphological changes in southern Disko Island

Ole Humlum

Field observations of the landscape were made in 2015 to identify geomorphological changes in southern Disko Island. The 2015 situation was compared with a collection of photographs and drawings from 1898, 1906, 1912, 1913, 1923, 1962, 1976, 1980, 1983, 1984, 1985, 1986, 1987, 1999, 2000, and 2001, respectively. The most important changes since 1898 have occurred for glaciers and late-summer snow patches. A number of mudflow channels have developed on talus slopes in the study area. But changes are also visible on smaller scale, e.g., on the surface cover of lichens and plants on rock outcrops and boulders. Some of these changes can be related to specific meteorological events within this time period, while others are the expression of more gradual climatic changes over time.

Ready for field work on the ice in Disko Bay. Photo Nina Lundholm

Education

Field and Methods Course in Physical Geography (1- 12 August 2015)

Teachers: Birger Ulf Hansen and Bo Elberling, Department of Geosciences and Natural Resource Management, University of Copenhagen, Denmark; Visiting professor Ole Humlum, Department of Geosciences, University of Oslo, Norway.

Students: Peter Bo Mähl, Søren Pierre Aagaard, Maja la Cour Bohr and Stinna Susgaard Filsø, University of Copenhagen, Denmark.

The purpose of the field course was to organize and carry out geographical independent fieldwork in an arctic environment and to be able to analyze, evaluate, document and communicate the results of this study in a scientific way. Part of the course was directly linked to CENPERM (see elsewhere in this report).

The aim of the Course was to investigate:
NDVI and nt-factors (describing relation between surface temperature and air temperature) on the Disko Island, Greenland, using different in situ methods.

The impact of different incorporated factors in Active Layer Thickness Modelling.

The combination of these two parts can provide new insight with respect to the current and future sediment transport and permafrost thawing within the study area taken current and future climate trends into account. The southern part of "Blæsedalen" was chosen as the study area due to the fact that the landscape is fairly well-described and due to the presence of all landscape types representative for the Arctic environment. Most of the collected samples were analyzed in the laboratory, while some were only pre-treated at the Arctic Station and brought back to Copenhagen for further analysis. The students performed statistical analyses, GIS-modelling and wrote scientific papers for the course report.

Findings and conclusions can be found in the report "Field and Methods Course in Physical Geography in 2015 at Disko Island, Greenland", which can be obtained free of charge from Birger Ulf Hansen (buh@ign.ku.dk) and as PDF from the Arctic station website.

CTD measurements from R/V Porsild. Photo Andreas Vieli

Arctic biology field course (7-17 July 2015)

Teachers: Kirsten S. Christoffersen (responsible) and Klaus P. Brodersen, Freshwater Biological Laboratory, Department of Biology, University of Copenhagen, Denmark

Students: Anna Hansen, Ditte Ethelberg-Findsen, Emil Kristensen, Jesper R. Schultz, Ditte M. Christensen, Kirstine Thiemer, Simone M. Mortensen, Nanna S. Petersen, Casper A. Pedersen, Anne J. Dobel and Henriette Hansen, University of Copenhagen, Denmark

The purpose of the field course was to allow the students to be acquainted with the arctic environment, they learned about in the course Arctic Biology, Institute of Biology, and to provide an opportunity to get experience with the process of creating a scientific research project from idea to a final report. The overall theme was Arctic Limnology. The students defined their group projects, researched the literature and prepared/tested methods for sampling and laboratory analysis before their field work.
Teaching on location included lectures and excursion to different sites nearby Arctic Station, exploration of the local village, lectures by guest scientists and the station manager at Arctic Station. All the experimental setups were established and sampling began immediately upon arrival. Field work continued throughout the stay and the collected samples were analysed in the laboratory. Few analyses needed to be done in the laboratory at Freshwater Biological Laboratory, University of Copenhagen, after the students returned to Denmark. This was followed by further data treatments, statistical analysis and preparing of the final reports.

Short outline of the group projects:
Species composition of Chironomidae in homothermic and heterothermic streams. Five steams of each type were sampled using standard methods for macroinvertebrates as well as water chemistry and the physical conditions. Temperature was monitored continuously for at least 24 h. The results showed no significant differences in the species composition between the "warm" and "cold" streams. Instead it seemed as Røde elv (a large river) was a local barrier for dispersal of chironomids.
Whole system metabolism in a lake and pond. The aim was to measure amplitudes in dissolved oxygen and from that to calculate the net and gross produc-

tion as well as the respiration of the entire ecosystem. It appeared that both sites were autotrophic meaning that carbon is stored. Based on existing data for the underwater light climate calculations for carbon fluxes during summer and winter were made.

Drepanocladus trifarius – an indicator of climate changes? Aquatic mosses are very common in shallow lakes and ponds in the Arctic. Their apical growth form can be used to determine annual growth and since previous year's biomass is kept it is also possible to reconstruct growth back in time. Growth of Drepanocladus trifarius from two ponds showed a correlation to mean summer temperature but not to other climate variables.

Zooplankton in Arctic lakes and the influence of arctic char (Salvelinus alpinus). The aim was to describe the zooplankton community structure in typical arctic lakes and to detect top down effects of fish. Standard fish and zooplankton investigation was carried out in 7 lakes (Moræneø, Porsild sø, Thygesens sø, and 2 lakes at Kangârssuk). Contrary to the expectations it was not possible to detect significant difference in the zooplankton composition between the locations. Local variations in abiotic conditions (bedrock, climate, distance to sea etc) are most likely the explanation. Interestingly, it was observed that major die-off of char had occurred in Porsild sø.

The Arctic Field Course at Arctic Station provides an optimal teaching environment where the students get a genuine understanding of how unique the arctic freshwater ecosystems are by observing and analysing themselves.

The findings and conclusions based on the student projects are published in the report "Arctic Biology Field Course - Qeqertarsuaq 2015" (in English). The report can be obtained from Kirsten S. Christoffersen (kchristoffersen@bio.ku.dk) and from the Arctic Station website as PDF.

An 18-min video about the course (in Danish) has been produced by Klaus P. Brodersen. It can be viewed from YouTube: http://www.youtube.com/watch?v=yxsb4A94UVc

New York University Abu Dhabi (NYUAD) Center for Sea-Level Change Greenland Field School

Organizers: David M. Holland, Denise Holland, Mathematics and Atmosphere Ocean Science, New York University, USA.

Participants: Brian Rougeux, New York University, USA and Irena Vankova, New York University Abu Dhabi

The purpose of the field school was:
To build a data set to understand Greenland's glaciers contribution to global sea-level change

Introduce students to working with CTD instrumentation in a hands-on manner.
To allow students to experience the types of research being carried out in Disko Bay.

To allow students to prepare and deploy and ocean glider in the Arctic waters off Ilulissat.

Students gather data and write reports on their trip and also present their experiences back in the USA and UAE to other undergraduate students who are interested in participating in future years.

To learn students about the Greenlandic culture, as well as the flora and fauna of the region.

We used three main types of oceanographic equipment, CTD, and moorings:
For CTD, we deployed a SeaBird 19Vplus, outfitted with oxygen, turbidity, and fluorescence sensors. Surveys were conducted across the width and breadth of the Disko Bay.

For mooring, we recovered a mooring at the mid-mouth of Disko Bay that we had deployed the previous summer.

We have tested an ocean glider which was deployed from the R/V Porsild and did several test runs. We also gained further experience using the glider software for understanding how to send the craft on longer deployments. We deployed a new mooring at the end of our cruise, using a new style of acoustic release.

Automatic weather station in Blæsedalen. Photo Charlotte Sigsgaard


CENPERM

Visits and public outreach

The Greenland Committee from the Danish Parliament (Christian R. Madsen, Karin Gaardsted, Peter Skaarup, Dennis Flydtkjær, Marcus Knuth, Eva Flyvholm, Carsten Bach, Josephine Fock, Annette Andersen) along with a member of the Ministry of Defense (Steen N.R. Nordstrøm), ombudsman in Greenland (Malene Engbo Andersen), a member of the district council (Kristian Broberg), and the Head of Service Center (Adolf Heilmann Davidsen) visited Arctic Station on 12 September 2015. The group had a guided tour around the Station and in Østerlien. Later this was followed up by a presentation of the history of Arctic Station and the various monitoring activities that are carried out here. The tour and the talk were given by Morten Rasch (former scientific leader at Arctic Station) and Charlotte Sigsgaard (both University of Copenhagen).

A group of architects, engineers and representatives of the University of Copenhagen (Thomas Riis, Birkir Rutsson, Henning Overgaard, Hans Halvorsen, Morten Rasch) visited the Arctic Station in September 2015 to look for possibilities to renovate and expand the Arctic Station.

A group of older citizens of Qeqertarsuaq visited Arctic Station on 15 October 2015 and got a guided tour by chief of logistics Kjeld Akaaraq Mølgaard.

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Scientific papers 2015

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People staying at Arctic Station early August 2015.

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